1307.7274.92 – 01

Test and Measurement Division

Technical Information

R&S® ZV-WR03 Calibration Kit

ROHDE&SCHWARZ

This technical information describes the following calibration kits:

- R&S® ZV-WR03 (without Sliding Match standard), stock no. 1307.7300.30
- R&S® ZV-WR03 (with Sliding Match standard), stock no. 1307.7300.31

The following abbreviations are used throughout this document:
R&S® ZV-WR03 is abbreviated as R&S ZV-WR03

Safety Instructions

This calibration kit has been designed and tested in accordance with the EC Certificate of Conformity and has left the manufacturer's plant in a condition fully complying with safety standards.

CAUTION **General safety instructions**

To maintain this condition and to ensure safe operation, you must observe all instructions and warnings given on this page.

Mechanical protection

The calibration kit (especially the waveguide flanges) must be protected against mechanical damage. Furthermore the waveguides must be shielded from dust.
While not mounted, protect the waveguide flanges by attaching the included caps. Avoid scratching the contact surfaces of the waveguide flanges.

Mounting a standard

The waveguide flanges of the standards are high-precision mechanical components that can be damaged by improper handling, e.g. canting of the flanges. Use a flat stable surface for your test setup and align the flanges accurately before mounting.

Opening the standards

Do not disassemble the standards. This applies especially to the sliding match standard consisting of several mounted parts. Repair can only be done at the manufacturer's servicing department.

Avoid heavy shocks

Heavy shocks can damage inner parts of the standards. Shock-proof packing should therefore be used for storing and dispatching of the calibration kit. Use the wooden box for this purpose.

Damage caused by cleaning agents

Cleaning agents contain substances that may damage the standards, e.g. solvent-containing cleaning agents may damage the labeling. Never use cleaning agents such as solvents (thinners, acetone etc.), acids, bases or other substances. Protect the waveguides from any liquids.
The outside of the standards is suitably cleaned using a soft, line-free dust cloth.

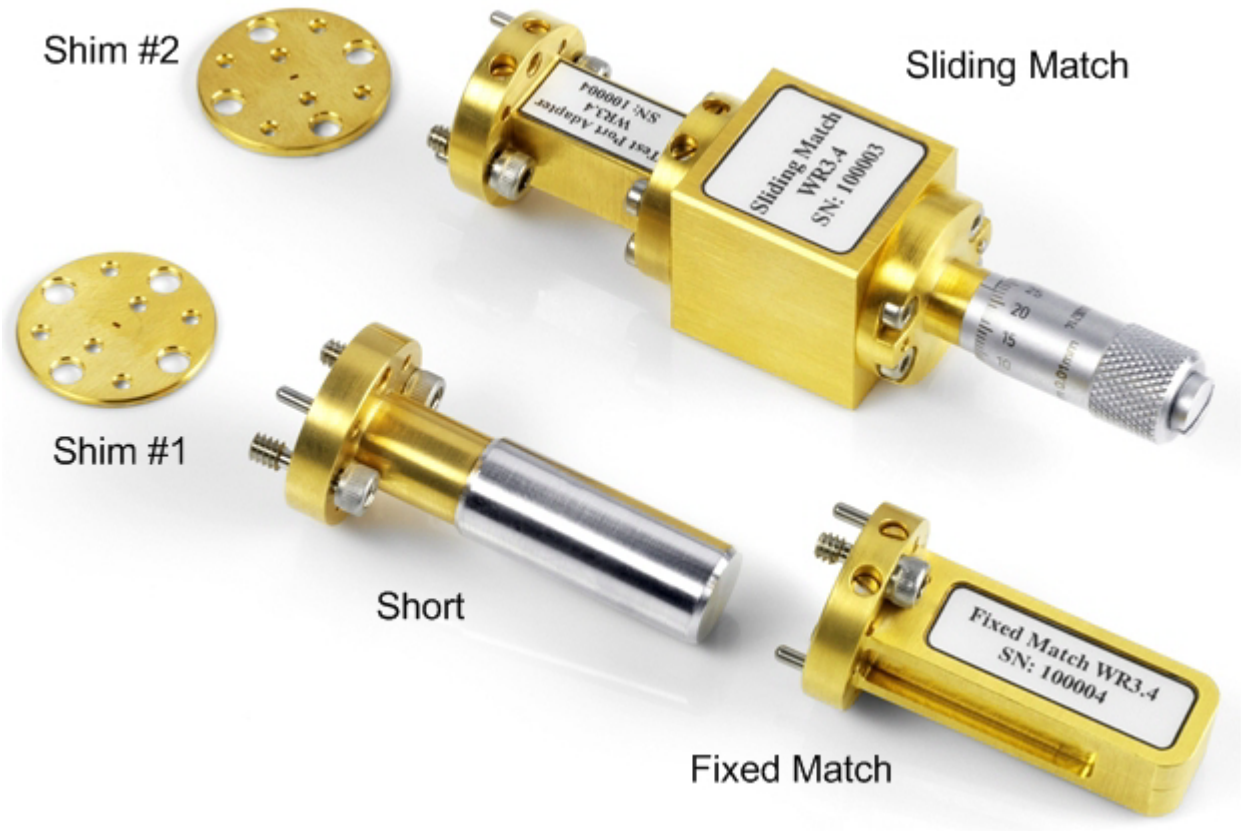
Damage level

The damage level of the calibration kit is listed in the data sheet. Exceeding this level may damage the calibration standards.

Calibration Kit R&S ZV-WR03

The waveguide calibration kit R&S ZV-WR03 allows to calibrate network analyzers for test setups involving frequency converters (in particular R&S ZVA-Z325).
The calibration kit contains the following standards:

- A Short standard which also serves as a Reflect standard
- A (Fixed) Match standard
- Two Shims containing a short transmission line. The length of the line equals 1 mm for Shim #1 and 1.371 mm for Shim #2. Both lines exhibit a λ/4 length difference around the center frequency of the converters operating range and a 180 deg phase shift of the reflecting coefficient.
- A Sliding Match standard (kit 1307.7300.31 only), providing more accurate results than the Fixed Match standard – at higher test effort.



The following table provides an overview of the available standards for rectangular waveguide calibration and the technical implementation using the calibration kit.

Standard Type	Technical Implementation
Open	Not available in waveguide technology, replaced by "Offset Short"
Short	Short + Shim #1, both contained in the calibration kit
Offset Short	Short + Shim #2, both contained in the calibration kit
(Fixed) Match	Contained in the calibration kit
Sliding Match	Contained in the calibration kit 1307.7300.31
Reflect	Short, contained in the calibration kit
Through	Through connection of the two waveguide flanges with Shim #1 in-between
Line 1	Through connection of the two waveguide flanges with Shim #2 in-between. In view of the bandwidth of the frequency converters, Line 2 is not needed.
Attenuation	Not contained in the calibration kit
Symmetrical Network	Not contained in the calibration kit

The standards in the calibration kit allow all one-port and two-port calibration types supported by the network analyzer except TNA.

The characteristic data of the standards are very stable and independent of the individual calibration kit. It is not required to deliver individual data with each kit and load the data into the analyzer. Instead the data are already stored in the network analyzer (software option K8 and at least firmware version 2.45 are required).
It is possible to export the stored data to a file. Use the "Cal-Kits" dialog of the network analyzer for this purpose: "Channel" > "Calibration" > "Cal-Kits" > "Export Kit ..."

Sliding Match Standard

The sliding match standard is only contained in the calibration kit 1307.7300.31. It is a one-port standard consisting of a precision waveguide section with a movable, low-reflection load element (sliding load). This standard is used because no perfect match is available. However, a series of measurements at a given frequency with equal mismatch and varying phase yields reflection factors that are located on a circle in the Smith chart. The center of this circle corresponds to perfect match. The network analyzer determines and further corrects this match point following I. Kása's circle-fitting algorithm.

To obtain the reflection coefficient for a perfectly matched calibration standard, the sliding load must be measured at least at three positions which should be unequally spaced to avoid overlapping data points. Increasing the number of positions to 4 – 6 can improve the accuracy. It is recommended to use the positions listed below. They are optimized for the frequency range between 220 GHz and 325 GHz. Set the adjustable screw of the standard to the following positions:
0 mm, 0.12 mm, 0.27 mm, 0.48 mm, 0.71 mm, 1.42 mm

If you accidentally unscrew the knob completely, simply screw it on again.

Performing a System Error Correction

Notes:

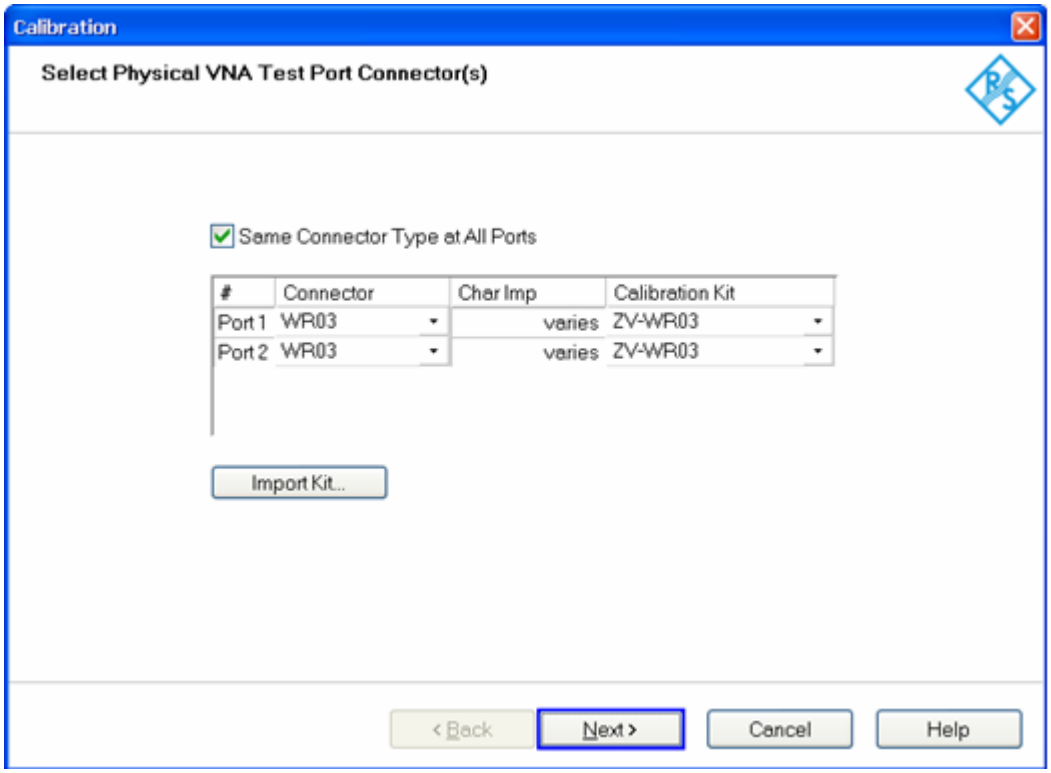
- Thermal fluctuations cause linear expansion of the waveguide components and result in phase drift. An environment with a stable temperature within the range stated in the data sheet is a prerequisite for accurate measurements.
- A power calibration must be performed previous to system error correction. Refer to the documentation of your frequency converter for instructions.
- If you readjust the output power of the frequency converter (using the knurled knob at the top of the converter) an already performed system error correction is no longer valid. For that reason adjust the output power of the frequency converter before system error correction.

TRL Calibration

The following example reports a TRL calibration for a four port R&S ZVA analyzer which is connected to two frequency converters. The test setup is described in the R&S ZVA-Z325 manual. It is suitable for transmission and reflection measurements on two-port waveguide DUTs in the frequency range of the converters.
The calibration procedure using the analyzer's "Calibration Wizard" is straightforward (for details refer to the analyzer help system, section "Guided Calibration"):

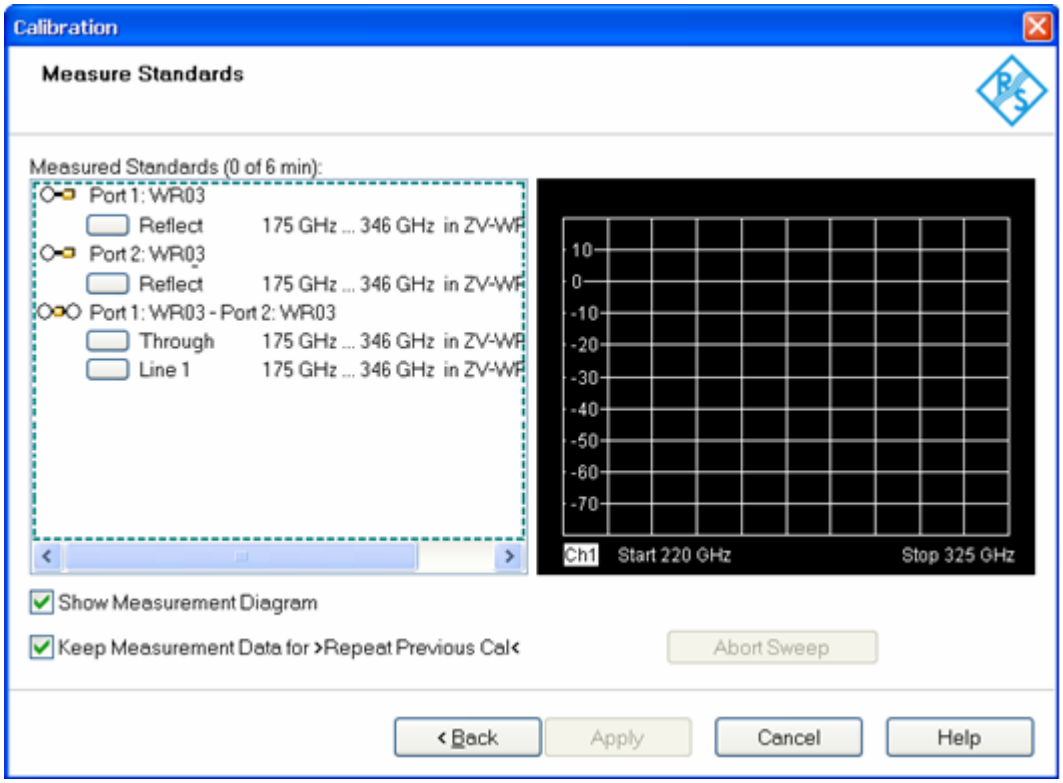
1. Activate the Frequency Converter Mode ("System" > "System Config…" > "Frequency Converter") and connect the two converters.
2. Click "Channel" > "Start Cal" > "Two Port P1 P2" > "TRL".

The calibration kit R&S ZV-WR03 is preinstalled. It is displayed in the "Select Physical VNA Test Port Connector(s)" dialog, together with the appropriate connector type.



Connector type and calibration kit selection

3. Click “Next” to proceed to the “Measure Standards” dialog.



4. Connect the Short standard from the calibration kit to the frequency converter no. 1 (the converter with RF IN connected to the analyzer port no. 1) and click “Port 1: WR03” > “Reflect” to initiate the calibration sweep.
5. Proceed in a similar way, using the Short at Port 2.
6. Establish the through connection using the Shim #1 between the ports.
7. Establish the line connection using the Shim #2 between the ports.
8. Click “Apply” to calculate and apply the system error correction data and close the wizard.

Tips: With calibration techniques involving a match standard (M) you can use the sliding match instead of the fixed match in order to improve the accuracy of the system error correction; see section Sliding Match Standard on page 5. Both standards cover the same frequency range.
You can check the calibration by measuring a standard that was not used during the system error correction (e.g. the fixed match to check a TRL calibration). Note that this check is incomplete (e.g. the transmission is not verified when using a one-port standard like a fixed match).

UOSM Calibration

UOSM calibration uses an unknown through[1] and yields two solutions related to different transmission phase values. The two solutions differ by 180 deg - only one solution is valid.
Within a coaxial system the analyzer selects the correct solution automatically. This is not possible in a waveguide system because the delay time is frequency-dependent (dispersive propagation). The valid solution has to be selected manually. For this purpose the following dialog opens during calculation of the system error correction data (see step 8 above):

Unknown Through Between Ports	Dispersive	Delay Time	Phase
Port 1: WR03 - Port 2: WR03	☑		-79.1°

Check “Dispersive” and select the right solution from the "Phase" drop-down list.

[1] Any two-port network whose S-parameters fulfill the reciprocity condition $s_{21}=s_{12}$ can be used as an unknown through (e.g. a waveguide bend).